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Regulation and Third-Party Discrimination in Vertically Related Markets: The Case of German Electricity

by

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**Diskussionsbeiträge des
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Critical comments to the author are welcome!

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***Abstract:** This paper explores the relation between the regulation of monopolistic upstream prices and the incentives of a vertically integrated input monopolist to discriminate third parties on the downstream market. Currently, this is an issue in network industries like telecommunications, electricity and railways and has sparked off a controversy in the literature. The paper examines how the incentives to discriminate depend on the level of the upstream prices, the potential competitiveness of the downstream market and the efficiency of the competitors as compared to the integrated firm's downstream subsidiary. The insights are applied to the electricity supply industry in Germany.*

JEL-classification: L42, L51, L94

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1. Introduction

In the 1960s the Chicago school of antitrust analysis convincingly contributed to the theoretical insights concerning vertically related markets [cf. Posner, 1979]. The basic argument is that if an input monopolist can compensate the loss in downstream profits resulting from downstream competition by means of higher upstream profits, it will not have an incentive to foreclose the downstream market.¹ In other words, it will not have an incentive to lever its market power from the monopolistic upstream stage to the competitive downstream stage. This sets an admittedly extreme reference case, which emphasises that an input monopolist will principally not have an incentive to behave discriminatorily, unless it has an explicit reason to do so.² A first reason is that downstream competition may be imperfect so that double marginalisation would result [Spengler, 1950]. Second, downstream competition might destroy a potential for

¹ Strict application of this insight has caused strong controversy in the Clear vs. Telecom antitrust case in the telecommunications sector in New Zealand; this ruling attracted renewed and equally controversial attention for the well-known efficient component pricing rule (ECPR) [cf. Baumol, Ordover & Willig, 1996; Patterson, 1998; Brunekreeft, 1999].

² For an overview of the theory see Perry [1989].

price differentiation which cannot be compensated from the upstream stage, due to a lack of information or a ban on price discrimination [Williamson, 1971; Fremdling & Knieps, 1993]. A third reason is the (sufficiently strong) regulation of the price of the monopolistic input. If the regulated price of the input is sufficiently close to upstream (marginal) costs, the integrated firm will not be able to compensate foregone downstream profits by higher upstream profits. The latter reason is the subject of a recent controversy in the literature and it is the purpose of this paper to provide further insight into this issue. The underlying question is not whether it is possible to discriminate against third parties, or whether it happens at all, but rather whether the upstream monopolist has an incentive to do so.

The reference case of the Chicago school has focussed on the perspective of antitrust analysis and consequently the disaggregated regulation of the monopolistic input prices as a reason for foreclosure has been somewhat neglected. It has gained substantial relevance, however, due to recent practical developments in network industries, like telecommunications and electricity, which combine regulation with antitrust policy. In the second half of the 1990s, a discussion arose in the USA, whether providers of local/regional telephone network companies should be allowed to integrate forward into the market for long-distance telephony, which had been prohibited after the break-up of AT&T. The local telephone network still is monopolistic to a large extent, whereas long-distance networks are competitive. Moreover, the local network is an essential input (originating or terminating) for long-distance calls. This highly relevant problem raised discussion concerning the incentives of the integrated local phone companies to discriminate against third parties (in this case, independent long-distance carriers). The situation in Europe is analytically equivalent but practically reversed; the incumbent telephone companies have never been broken up like AT&T, and they are thus already vertically integrated. This changes the perspective on who is the entrant and who the incumbent in the long-distance market.

For Europe, the electricity sector provides a very nice case study. The liberalisation of European electricity markets is based on the EU-directive

concerning a common electricity market.³ With respect to network access, the directive leaves an option between negotiated and regulated third party access (TPA).⁴ Germany is the only member state to have chosen negotiated TPA. In practice this implies that the network-access charges are unregulated, whereas issues concerning undue discrimination against third parties are left to the antitrust agency. The antitrust agency appears well equipped to handle discrimination, but is poorly equipped to regulate the level of the network access charges. All other member states have opted for regulated TPA and have subsequently installed a sector-specific regulator, which among other things caps the access charges.⁵

The concerns about the integration of the local telephone companies into the long-distance market in the USA triggered an interesting controversy about the effects of the regulation of the monopolistic input price on the incentives of an integrated firm with an upstream monopoly to discriminate against its downstream competitors. Weisman [1995] gives a rich and dense formal analysis of the problem and stresses the difference between the opportunity and the incentive to discriminate against third parties. Thereby, he tones down the concern about discrimination and emphasises that the incentives to discriminate should be shown to exist rather than be taken for granted. Notwithstanding these important contributions, Weisman's [1995, p. 257] result 5 suggests that an upstream monopolist has no incentive to discriminate against third parties, *irrespective* of the (regulated) level of the input price, which is counterintuitive. In a response, Reiffen [1998] argues that Weisman's proof of his result 5 is not complete and that if the input price is regulated sufficiently strongly the input monopolist does have an incentive to discriminate against third parties. Reiffen [1998] emphasises that whether the incentives exist or not depends on the empirical magnitudes. In reply to Reiffen [1998], Weisman [1998, p. 88]

³ Directive 96/92/EC, which came into force on 19 February 1997, setting a two year target for transformation into national legislation.

⁴ Third parties are competitors at the retail and generation stages, which need access to the networks as an essential facility.

⁵ The situation of the German railways provides another excellent study. Limitation of space does not permit to be extensive, but the interested reader may be referred to Berndt & Kunz [2000] for a detailed discussion.

clarifies his focus but holds on to his original claim. As suggested by Beard, Kaserman & Mayo [2000, p. 3], the problem with Weisman's argument appears to be an implicitly used assumption that the integrated firm's downstream market share is fixed and possibly small. Obviously, however, third-party discrimination aims at increasing the integrated firm's downstream market share. An elegant extension naturally follows with Sibley & Weisman [1998], where a dynamic approach has been applied. The integrated firm's downstream sales are capacity constrained and capacity can only grow at some predetermined speed. This approach stresses the trade off between upstream and downstream profits resulting from third-party discrimination.⁶

Result 3 of Sibley & Weisman [1998, p. 460] suggests that -in steady state- it is always profitable to discriminate against third parties, apparently also if the input price is unregulated. A similar conclusion comes from Economides [1998, proposition 3, p. 281] as quoted by e.g. Reiffen [1998], Sibley & Weisman [1998] and Beard, Kaserman & Mayo [2000]. This proposition is strongly opposed by Bergman [2000],⁷ who points out a technical problem. Bergman [2000, p. 986] emphasises the special nature of the application of non-price discrimination: in profit optimisation it is likely to be a minimum rather than a maximum. Independently of Bergman, Mandy [2000] exploits this property. For the model below this point is crucial and will receive detailed attention. Indeed, non-price discrimination (if costless for the discriminating firm) appears to be discontinuous in nature: the integrated firm either refrains from discrimination or attempts to foreclose the market completely.

Following Reiffen [1998], Reiffen, Schumann & Ward [2000], Beard, Kaserman & Mayo [2000] and Mandy [2000], the current state of consensus with respect to the reference case seems to be that the unregulated upstream monopolist will not have an incentive to discriminate against third parties, while if the upstream prices are regulated sufficiently strongly the incentive to discriminate against

⁶ Here the difference between who is the entrant and who is the incumbent is important. For the European context the approach would have to be reversed, because here the integrated firm is the incumbent.

⁷ Economides [2000] replies to Bergman [2000] by stressing that his analysis rests on the assumptions of imperfect downstream competition and regulation of the input price.

third parties does emerge. This paper relies on this view and provides further insight and explores the natural question following from it: how high is the access charge at which the upstream monopolist would be exactly indifferent? Strong emphasis will be put on the point where various effects are exactly zero. At this point the input price is exactly such that the upstream monopolist would exactly not have an incentive for third-party discrimination, while simultaneously no entry takes place because the profit margin at the downstream stage is exactly zero. The incentives basically balance between two effects: imperfect downstream competition, which by the effect of double marginalisation decreases some profit potential, and higher efficiency of the competitors, which increases upstream profits. The (regulated) level of the input price determines which of the two effects dominates. Hence, it seems fruitful to explore the relation of the input price and the degree of (downstream) competitiveness and relative downstream efficiency. Section 2 will present the model, whereas section 3 characterises the solutions. Section 4 examines the electricity supply industry in Germany as a topical case study. Section 5 concludes.

2. *The model*

The terminology used below is borrowed from network industries. The output of the upstream monopoly (which is an essential input to the downstream firms) is called "access" to the network, and the associated price is called "access charge". The approach as such, however, applies equally to non-network industries. Furthermore, denote:

$P(nq_E, Q_I)$	inverse demand for good Q with price P
r	access charge
z	indicator for third-party discrimination
$C^U(Q)$	upstream costs
MC^U	constant upstream marginal costs
$C_I^D(Q_I)$	downstream costs of firm I
MC_I^D	constant downstream marginal costs of firm I

$C_E^D(q_E)$	downstream costs of a firm E
MC_E^D	constant downstream marginal costs of a firm E (<i>net</i> of the costs of the access charge and the costs of third-party discrimination)
n	number of competitors/entrants E
$Q_E = nq_E$	total output of the competitors
$Q = Q_I + Q_E = Q_U$	
superscript U	upstream
superscript D	downstream
subscript I	incumbent/integrated firm
subscript E	entrant(s)/competitor(s)

Fixed costs are ignored; they would complicate notation without providing additional insight for the purpose of this paper. The lack of fixed costs plus the assumption of constant downstream marginal costs implies constant returns to scale. Both the end-product price P and the access charge r are assumed to be uniform. Consequently, there is no price differentiation in any form. The downstream and upstream output are assumed to be strictly complementary; moreover, to simplify notation, the ratio of the two outputs can be normalised to 1, such that $Q = Q_I + Q_E = Q_U$. These three conditions basically underlie the Chicago school reference case. Note that the integrated firm's downstream subsidiary and its competitors are allowed to differ in efficiency by their respective marginal costs. The degree of competitiveness on the downstream market will be varied comparatively statically by using n as the number of competitors; n goes from 1 to infinity.

The first step is to solve the downstream stage conditional upon r and z . Define an entrant's profit function:

$$\pi_E(q_E) = (P(\cdot) - MC_E^D - z - r)q_E \quad (1)$$

The first-order condition w.r.t. q_E is:

$$\frac{\partial \pi_E}{\partial q_E} = \frac{\partial P}{\partial q_E} q_E + P - MC_E^D - z - r = 0 \quad (2)$$

Recalling that $nq_E = Q_E$, it follows that *derived demand* from the entrants is:

$$Q_E^* = -n \frac{\partial q_E}{\partial P} (P - MC_E^D - z - r) \quad (3)$$

The constrained optimisation problem for the integrated firm is as follows:

$$L_I(Q_I, r, z) = P \cdot Q_I + r \cdot Q_E^* - MC_I^D \cdot Q_I - MC^U \cdot (Q_I + Q_E^*) - \lambda_1 \cdot r + \lambda_2 \cdot Q_E^* + \lambda_3 \cdot Q_I. \quad (4)$$

The first line after the equation sign depicts the integrated firm's profit from selling the end-product with quantity Q_I and selling the intermediate product with quantity Q_E^* . It may be noted that the intra-firm transaction of the intermediate output drops out in this formulation. The costs of the access charge to the integrated firm's downstream department are revenue for the upstream department.⁸ The second line describes three constraints. The first constraint states that the access charge should be lower than or equal to some fixed level: $r \leq \bar{r}$. This is relevant if the access charge is (bindingly) regulated; if the access charge is unregulated, λ_1 will be equal to zero by definition. The second and third constraints are technical constraints which state that output cannot be negative: $Q_E \geq 0$ and $Q_I \geq 0$. The formulation of the problem is a Stackelberg-formulation. It seems natural to assume that the upstream-department realises and internalises the downstream-competitors' reactions to Q_I , r and z . Assuming strict Cournot competition at the downstream stage would run into the problem that the integrated firm would expect the competitors to react to changes in r and z , but not to changes in Q_I , which may not be entirely consistent.⁹

⁸ The intra-firm price of the intermediate product only plays a role if, by accounting separation, the upstream- and downstream-departments have separate books and if (one of) the department's profit is regulated separately. Otherwise the intra-firm price may be important for management decisions but is irrelevant for regulatory purposes. Here, since there are no constraints such as accounting separation, the intra-firm transaction necessarily drops out. This implies that the integrated firm does not (in contrast to what is often claimed) charge its own downstream subsidiary less than third parties; the additional profit of the downstream subsidiary is equivalent to an additional loss of the upstream department. See further Allen [1971, pp. 256-257].

⁹ The strategic assumptions are discussed in some detail in Beard, Kaserman & Mayo [2000, p. 7].

Some preliminaries are desirable. Taking the total differential of (3), using $P(Q_E^*, Q_I)$:

$$dQ_E^* = -n \frac{\partial q_E}{\partial P} \left(\frac{\partial P}{\partial Q_E} dQ_E^* + \frac{\partial P}{\partial Q_I} dQ_I - dr - dz \right) \quad (5)$$

Now, a restrictive but considerably simplifying assumption is made. Due to the structure of the problem (i.e. Stackelberg and differing marginal costs) the solution will be typically asymmetrical. The problem is that for non-linear demand, nothing guarantees that:

$$\frac{\partial P}{\partial q_E} = \frac{\partial P}{\partial Q_E} = \frac{\partial P}{\partial Q_I} = \frac{\partial P}{\partial Q}. \quad (6)$$

From (5), it can be seen that notation will become very cumbersome if properties (6) cannot be used. For this reason, the rest of this paper will assume linear demand, so that properties (6) hold. This assumption simplifies notation considerably, while it is not obvious that it results in a significant loss of generality. Using (6) and taking $dr = dz = 0$, rewriting (5) then results in:

$$\frac{dQ_E^*}{dQ_I} = -\frac{n}{n+1}. \quad (7)$$

The conjecture on downstream competitive behaviour depends on the number of firms. It can be seen that if n is large, the value goes to -1, which represents Bertrand-like (perfect) price competition, whereas $n = 1$ represents a Stackelberg duopoly. This approach is desirable because the competitiveness of the downstream market determines the degree of double marginalisation. The integrated firm can gain from more efficient competitors by raising the access charge. Double marginalisation takes away part of these gains, which in turn lowers the incentive to allow the competitors on the market. The effect of double marginalisation may be taken as a proxy for other reasons why the upstream monopolist would not be able to compensate downstream losses fully by additional upstream profits.

With (7), it follows from $P(Q_I, Q_E^*(Q_I))$:

$$\frac{dP^*}{dQ_I} = \left(\frac{1}{n+1} \right) \frac{\partial P}{\partial Q}. \quad (8)$$

Taking the first derivative of L w.r.t. Q_I , using (7) and (8) and rewriting then gives:

$$Q_I^* = -\frac{\partial Q}{\partial P} \left[(n+1)P - nr - (n+1)MC_I^D - MC^U - n\lambda_2 + (n+1)\lambda_3 \right]. \quad (9)$$

The second step is to solve for the upstream stage, given conditional optimal values on the downstream stage. From (5) it follows:

$$\frac{dQ_E^*}{dr} = \frac{n}{n+1} \left(\frac{\partial Q}{\partial P} - \frac{dQ_I^*}{dr} \right) \quad \text{and} \quad \frac{dQ_E^*}{dz} = \frac{n}{n+1} \left(\frac{\partial Q}{\partial P} - \frac{dQ_I^*}{dz} \right). \quad (10)$$

Taking the total differential of (9) gives:

$$dQ_I^* = -\frac{\partial Q}{\partial P} \left[(n+1)(dQ_I^* + dQ_E^*) \frac{\partial P}{\partial Q} - ndr \right], \quad (11)$$

Using (11) and (10) and rewriting results in:

$$\frac{dQ_I^*}{dr} = 0, \quad \frac{dQ_E^*}{dr} = \left(\frac{n}{n+1} \right) \frac{\partial Q}{\partial P}, \quad \text{and} \quad \frac{dP^*}{dr} = \left(\frac{dQ_I^*}{dr} + \frac{dQ_E^*}{dr} \right) \frac{\partial P}{\partial Q} = \frac{n}{n+1}. \quad (12)$$

and similarly,

$$\frac{dQ_I^*}{dz} = -\frac{n}{2} \frac{\partial Q}{\partial P}, \quad \frac{dQ_E^*}{dz} = \left(\frac{n}{n+1} \right) \left(\frac{n+2}{2} \right) \frac{\partial Q}{\partial P}, \quad \text{and} \quad \frac{dP^*}{dz} = \frac{1}{2} \frac{n}{n+1}. \quad (13)$$

Note in particular that Q_I^* is independent of the access charge. In (9), r turns up as a direct effect, but this is compensated by the indirect effect through P^* . Note that for the case of perfect price competition, an increase in the access charge is fully passed through into the end-user price. Alternatively, for imperfect

competition, marginalisation causes the increase in the access charge to be passed through in the end-user price only partly.¹⁰

The first-order derivative of L w.r.t. r results in:

$$Q_E^* + \frac{n}{n+1} Q_I^* + \frac{n}{n+1} \frac{\partial Q}{\partial P} [r - MC^U + \lambda_2] - \lambda_1 = 0. \quad (14)$$

And derivation of L w.r.t. z gives:

$$\begin{aligned} & \frac{n}{2(n+1)} Q_I^* - \frac{n}{2} \frac{\partial Q}{\partial P} [P^* - MC_I^D - MC^U + \lambda_3] \\ & + \frac{n}{(n+1)} \frac{(n+2)}{2} \frac{\partial Q}{\partial P} [r - MC^U + \lambda_2] = 0. \end{aligned} \quad (15)$$

It is important to check the second-order condition of L w.r.t. z :

$$-\frac{1}{2} \frac{n^2}{n+1} \frac{\partial Q}{\partial P} > 0. \quad (16)$$

The second-order condition of the maximisation problem with respect to z is positive rather than negative, which implies that an optimum for z is a minimum, rather than a maximum.¹¹ This in turn implies that (15) cannot be used. This problem has been noted by Bergman [2000, p. 986] and Mandy [2000, p. 164], who conclude -for the unregulated case- that the integrated firm will either set $z = 0$ or set z sufficiently high so that the potential entrants do not enter (foreclosure). Though surprising, the intuition is straightforward. The meaning of z in this setting is that it increases the competitors' costs for $z > 0$, and decreases the costs of competitors for $z < 0$. Lower costs of the competitors can be transformed into profit for the integrated firm if it can compensate the loss in its downstream sales by raising the access charge. In other words, efficient competitors will as a rule not be foreclosed because their presence raises the profits for the upstream department (provided that it can determine the access

¹⁰ These effects implicitly assume that $\lambda_2 = 0$. If not, the corresponding corner solution gives $Q_E^* = 0$ and thus $dQ_E^* = 0$. By (10) this implies $\frac{dQ_I^*}{dr} = \frac{dQ_I^*}{dz} = \frac{\partial Q}{\partial P}$ and the expressions in (12) and (13) change accordingly.

¹¹ It can be checked that the second-order conditions w.r.t. Q_I and r are negative. Thus the Hessian determinant is indefinite, which overall gives a saddle point.

charge freely). This sets an incentive to decrease z , in principle to negative values. It is not obvious, however, what a negative z means in practice and it seems natural to assume that $z = 0$ is the lower limit.¹² The same idea applies for increasing z if the competitors' output could be negative (which would imply that the integrated firm's downstream department would produce more than the total output). Rather than increasing the access charge, the access charge would be lowered. Because the competitors' output is negative and because the end-product price P is larger than the access charge r , the additional profit for the integrated firm's downstream department would more than offset the additional loss of the upstream department. With negative competitors' output, all effects are reversed. Consequently, the integrated firm would have an incentive to increase z , provided that Q_E could be negative. Of course, output cannot be negative, which explains why a subsequent constraint has been included in the LaGrange-formulation in (4). It follows that, for unconstrained access charges, z will either be zero or will be set such that the downstream market is foreclosed. The insight that z will be either of these two corner solutions suggests that the solution to the maximisation problem is discontinuous. Which of the two solutions prevails depends upon the level of the access charge r and thus upon whether or not the access charge is regulated.

3. *Characterisation of the solution*

Section 2 presented the basic approach in quite general notation. For detailed characterisation of the solution it is more convenient to apply a parametric specification of demand. Since demand has been assumed to be linear, a parametric specification will not cause an additional loss of generality. Define inverse demand as:

$$P(Q) = a - bQ.$$

The outline of the solution is as follows. Denote the foreclosure benchmark with the superscript "F" and thus the level of z at which the downstream market is

¹² The integrated firm could in principle subsidise competitors ($z < 0$), but this would imply additional costs for the integrated firm and the analysis would have to be modified accordingly.

perfectly foreclosed by z^F . Perfect foreclosure means an entry barrier (by means of z) sufficiently high to allow the incumbent any downstream profit margin it wishes without attracting new entry. Minimal foreclosure in contrast means a z at which competitors do not enter, but simultaneously does not allow a positive downstream profit margin for the integrated firm. It will be shown first that if the access charge is unconstrained, it is profit maximising to set $z = 0$. Second, in case the access charge is regulated down to the marginal upstream costs, it will be profitable to use a z such that the downstream market is perfectly foreclosed. Third, there must be some level of the access charge at which the integrated firm is just indifferent between $z = 0$ and $z = z^F$.

Equalising (3) and (14) w.r.t. Q_E^* gives:

$$r^* = \frac{1}{2} \left(a - MC_E^D - z + MC^U - \lambda_2 - \lambda_1 b \frac{n+1}{n} \right) \quad (17)$$

Taking (9), while substituting (3), results in:

$$Q_I^* = \frac{a + nMC_E^D + nz^* - (n+1)MC_I^D - MC^U - n\lambda_2 + (n+1)\lambda_3}{2b}. \quad (18)$$

From writing out (14), while substituting (18), it follows:

$$Q_E^* = \frac{n}{2b} \left(MC_I^D - MC_E^D - z^* + \lambda_2 - \lambda_3 + \frac{b}{n} \lambda_1 \right) \quad (19)$$

Adding (18) and (19) gives:

$$Q^* = \frac{1}{2b} \left(a - MC_I^D - MC^U + \lambda_3 + b\lambda_1 \right), \quad (20)$$

and thus:

$$P^* = \frac{a + MC_I^D + MC^U - \lambda_3 - b\lambda_1}{2}. \quad (21)$$

3.1 The extremes: the unregulated case ($\lambda_1 = 0$) and the regulated case ($\lambda_1 > 0$)

First, the cases with respect to λ_2 and λ_3 should be demarcated. There are four cases: a) $\lambda_2 = \lambda_3 = 0$, b) $\lambda_2 > 0$, $\lambda_3 = 0$, c) $\lambda_2 = 0$, $\lambda_3 > 0$ and d) $\lambda_2 > 0$, $\lambda_3 > 0$.

Case d) can be excluded immediately, because it is a contradiction; it would imply that both the integrated firm's output and the competitors' output are equal to zero. Suppose case a). From (19), this can only be consistent if $MC_I^D \geq MC_E^D$. If $MC_I^D < MC_E^D$, Q_E^* would be negative which in turn implies that λ_2 is larger than zero, which contradicts the assumption. It may be concluded immediately, that if the competitors are less efficient than the integrated firm, they will not enter. This is the result of the access charge, however, and not of z . Furthermore, for the case that $MC_I^D > MC_E^D$, case b) is a contradiction. It would imply that $Q_E^* = 0$, which as can be seen from (19) is only possible with $\lambda_3 > 0$. Consequently, we may concentrate on the case $MC_I^D > MC_E^D$ and case c), which implies that $Q_E^* > 0$ (and $\lambda_2 = 0$). Within this case, λ_3 may be larger than or equal to zero; i.e. $Q_I^* \geq 0$. The latter depends on the number of competitors, n . If n is small, $Q_I^* > 0$, while if n is large $Q_I^* = 0$. There is a critical number of competitors \tilde{n} , beyond which $Q_I^* = 0$. This bordercase can be calculated by equalising Q_E^* and Q_I^* (i.e. (19) and (20)) and substituting $\lambda_2 = \lambda_3 = 0$:

$$\tilde{n} = \frac{a - MC_I^D - MC^U}{MC_I^D - MC_E^D}. \quad (22)$$

This number \tilde{n} will normally be larger than 1, and for $MC_I^D > MC_E^D$ smaller than ∞ . The expression as such is not very insightful, but it suggests that for a Stackelberg duopoly, the integrated firm will remain active on the downstream market, whereas under price competition, it may withdraw from the downstream market (actually, it would like to produce a negative quantity). If the integrated firm were to withdraw from the market in case $n = 1$, it would give way to a (downstream) monopoly which would result in double marginalisation. With large n , the offsetting effect of double marginalisation vanishes, and by withdrawing from the market and raising the access charge the integrated firm can internalise all efficiency gains stemming from the presence of more efficient competitors. The following concentrates on the two bordercases: $n = 1$ and $n \rightarrow \infty$. Denote the case of $n = 1$ with superscript "S" for Stackelberg and the case $n \rightarrow \infty$ with superscript "B" for Bertrand-competition.

Result 1: if the access charge is not regulated, the integrated firm will -as a reference case- not have an incentive to apply third-party discrimination against (more efficient) downstream competitors.

The proof is in appendix 1, which shows that for an unconstrained access charge, profit for $z = 0$ is higher than for $z = z^F$ which perfectly forecloses the downstream market. To characterise the solution further, it can thus be taken that $z = 0$. Denote the non-regulated outcome with the superscript "NR"

Using $\lambda_1 = 0$, $\lambda_2 = 0$ and $MC_I^D \geq MC_E^D$, it follows from (17) that:

$$r^{NR} = \frac{a - MC_E^D + MC^U}{2}. \quad (23)$$

Moreover, since as shown above for $n = 1$, $Q_I^* > 0$, $\lambda_3 = 0$, it follows that:

$$P^S = \frac{a + MC_I^D + MC^U}{2}. \quad (24)$$

For $n \rightarrow \infty$, λ_3 has to be derived from (9) by setting $Q_I^* = 0$:¹³

$$\lambda_3 = -\frac{1}{n+1} \left(a + nMC_E^D - (n+1)MC_I^D - MC^U \right), \quad (25)$$

from which then follows that:

$$P^B = \frac{a + MC_E^D + MC^U}{2}. \quad (26)$$

Especially the expression for r^{NR} in (23) deserves some attention. It shows that the unregulated access charge reflects the marginal costs of the competitors, rather than the marginal costs of the integrated firm's downstream subsidiary. r^{NR} also serves as the internal transfer price, which reflects the best alternative option, i.e. the external price. It reflects the insight that the integrated firm attempts to internalise the efficiency gains associated with the more efficient competitors. It will welcome the presence of the more efficient competitors if it can turn the efficiency gain into higher upstream profits. Note that the profit-maximising access charge increases with lower competitors' marginal costs.

¹³ Note that $\lambda_3 > 0$ for n sufficiently large and $MC_I^D \geq MC_E^D$.

From (24) it can be seen that the competitor ($n = 1$) will make a profit, because the margin between the end-user price and the access charge is larger than the competitor's marginal costs. Thus, despite (partly) double marginalisation, the integrated firm does not have an incentive to foreclose the downstream market. The increase in upstream profits is sufficiently high to offset the effect of double marginalisation. Note, however, that the downstream profit margin is lower than the integrated firm's downstream marginal costs. The integrated firm strikes a balance between the two offsetting effects and it illustrates that its downstream strategy is to discipline the competitor's incentive to set a downstream mark up. In case of price competition (n is large) the effect of double marginalisation vanishes and thereby this trade off vanishes. For large n , the competitors do not make a profit since the profit margin exactly equals the marginal costs of the competitors. In other words, the efficiency gain is completely transformed into higher upstream profits.

It is insightful to evaluate the integrated firm's profit with respect to the number of competitors, n . Note that $\frac{dr^{NR}}{dn} = 0$ and as long as $\lambda_3 = 0$ (i.e. n is small),

$\frac{dP^S}{dn} = 0$. From (18) and (19), it follows:

$$\frac{dQ_I^*}{dn} = \frac{MC_E^D - MC_I^D}{2b} \quad \text{and} \quad \frac{dQ_E^*}{dn} = \frac{MC_I^D - MC_E^D}{2b}, \quad (27)$$

which implies:

$$\frac{d\pi_I^{NR,S}}{dn} = (P^S - r^{NR} - MC_I^D) \frac{dQ_I^*}{dn} + (r^{NR} - MC^U) \frac{dQ_E^*}{dn} = \frac{(MC_E^D - MC_I^D)^2}{4b} > 0. \quad (28)$$

This applies for $MC_I^D \geq MC_E^D$ only. For $n \rightarrow \infty$, $Q_I^* = 0$ and $Q_E^* = Q^*$ and all profits for the integrated firm are derived from the access charges:

$$\frac{d\pi_I^{NR,B}}{dn} = 0. \quad (29)$$

Thus starting from the $n = 1$ outcome, it can be seen that the profit of the integrated firm increases with n ; the stronger the downstream competition, the

higher the profit of the integrated firm.¹⁴ This is again the effect of double marginalisation, which vanishes with stronger downstream competition. It should be stressed, that stronger downstream competition can be profitable for the integrated firm because it can compensate lower downstream profits by higher upstream profits. If alternatively the access charge is regulated sufficiently strongly, this will no longer be possible and the incentives are reversed.

Result 2: if the access charge is regulated sufficiently strongly, the integrated firm will have an incentive to foreclose the downstream market by means of third-party discrimination.

The proof is given in appendix 2. The intuition is straightforward. Suppose that the access charge is regulated down to the upstream marginal costs, such that (excessive) upstream profits are not possible. In this case, foregone profits on the downstream market can never be compensated by additional profits on the upstream market. Thus the integrated firm will have an incentive to lever its upstream market power to the downstream market in order to make profits on the downstream market, irrespective of the efficiency of the competitors. It achieves this by third-party discrimination. Obviously, the argument also holds if the regulated access charge is marginally higher than upstream marginal costs.

The case of regulation is relatively simple.¹⁵ Note, however, that $\lambda_2 = 0$ and $z = 0$ can no longer be assumed. To characterise the regulated case, i.e. $r = \bar{r}$, it is convenient to derive P^R , where the superscript "R" denotes "regulated". Recall that this means "the end-user price which results under binding regulation of the access charge", and not "the regulated end-user price"; in the approach employed in this paper, the end-user price is not regulated. P^R can be derived from Q^R , which in turn can be found by adding Q_I^R and Q_E^R , i.e. adding (9) and (3):

$$P^R = \frac{a + 2n\bar{r} + (n+1)MC_I^D + nMC_E^D + MC^U + n\lambda_2 - (n+1)\lambda_3 + nz^*}{2(n+1)}. \quad (30)$$

¹⁴ See also Sibley & Weisman [1998, p. 466].

¹⁵ As Beard, Kaserman & Mayo [2000, p. 13] correctly put it: "Fortunately, this regulatory "complication" actually results in a far simpler problem".

The benchmark case for $n = 1$, $\bar{r} = MC^U$, $z = 0$ (although this would not be the firm's choice), cost symmetry ($MC_I^D = MC_E^D = MC^D$) and using $\lambda_2 = \lambda_3 = 0$ provides a feel for this expression. Substituting the assumed values in (30) gives:

$$P^{R,S} \Big|_{MC^D} = \frac{a + 3MC^U + 3MC^D}{4}, \text{ and } Q_I^{R,S} = \frac{2}{3} Q^{R,S} \text{ and } Q_E^{R,S} = \frac{1}{3} Q^{R,S}, \quad (31)$$

which corresponds to the familiar Stackelberg outcome.¹⁶

3.2 The switching level of the access charge

In section 3.1 it has been shown that the profit for the unregulated access charge with $z = 0$ is larger than for $z = z^F$ which would foreclose the downstream market completely. It has been shown moreover, that if $\bar{r} = MC^U$, the profit of the integrated firm is lower with $z = 0$ than with $z = z^F$. Consequently, there will be a level of the access charge at which the integrated firm will be indifferent between $z = 0$ and $z = z^F$. In other words, if the access charge is regulated below this critical level, the integrated firm will switch from having no incentive to having a strong incentive to apply third-party discrimination. Let this critical level of the access charge be ρ .

The switching level of the access charge should be calculated for the two different cases $\lambda_3 = 0$ (and $Q_I^* > 0$) and $\lambda_3 > 0$ (and $Q_I^* = 0$), in dependence of n . The way to proceed is by equalising the profits of the integrated firm under $z = z^F$ with the profits for the integrated firm under $z = 0$ and solve this for ρ . The derivation of the solutions (see appendix 3) turns out to be cumbersome and the solution itself rather unintuitive. The value of ρ for $n < \tilde{n}$, which may be denoted by ρ_1 is:

$$\rho_1 = \frac{a - MC_E^D + MC^U}{2} - \frac{\sqrt{(n+1)}(MC_I^D - MC_E^D)}{2}, \quad (32)$$

¹⁶ Note, however, that, due to imperfect downstream competition, $r = MC^U$ is above the welfare-maximising access charge; compare also Vickers [1995].

and for $n \rightarrow \infty$, which may be denoted by ρ_2 :

$$\rho_2 = \frac{a - MC_E^D + MC^U}{2} - \frac{\sqrt{(MC_E^D - MC_I^D)^2 - 4bQ^F(MC_E^D - MC_I^D)}}{2}. \quad (33)$$

where in (33), $Q^F = \frac{a - MC_I^D - MC^U}{2b}$, i.e. the output which results if the integrated firm is alone. The first part in both (32) and (33) represents the unregulated access charge, r^{NR} , as in (23); thus, ρ is expressed relative to the unregulated access charge. Even if these expressions cannot be readily interpreted, one feature is striking and important. For $MC_I^D = MC_E^D = MC^D$, the second term in both expressions is zero, and thus $\rho_1 = \rho_2 = r$.

Result 3: If the integrated firm's downstream subsidiary and its competitors are equally efficient and if the access charge is unregulated, the integrated firm will be exactly indifferent with respect to third-party discrimination, irrespective of the potential degree of downstream competitiveness. It follows at the margin, that although the integrated firm's behaviour is non-discriminatory, entry does not take place, simply because the profit margin is too small.

In other words, if the integrated firm's downstream subsidiary and the competitors are equally efficient, everything comes together in one point. At the margin, the integrated firm will not have an incentive to apply third-party discrimination if the access charge is at the unregulated level. Thus if the entrants are (merely) equally efficient and the access charge is unregulated, a situation in which the potential entrants do not enter although $z = 0$. In other words, new entry will be minimal, whereas the behaviour of the integrated firm is *not* discriminatory. The access charge may be monopolistically high, but this applies equally to third parties and to the integrated firm's downstream subsidiary. Entry is simply not attractive because the downstream profit margin is too small. One may consider this situation as if the upstream management puts its own downstream subsidiary in a contestable position. If the downstream subsidiary would live a life of its own, in order to survive it should not set a

mark-up above marginal costs and it should produce efficiently.¹⁷ From an efficiency perspective, given that the access charge is unregulated and that the third parties are no more efficient than the integrated firm's downstream subsidiary, there is no need for actual competition. If, on the other hand, (active) competition per se is desired, the result is rather problematic.

The result is not robust, however. If the access charge is regulated only slightly below the unregulated level (given equally efficient firms), the integrated firm will have an incentive to foreclose the downstream market.¹⁸ Thus, one should actually question the meaning of the expression "competition", as the counterpart of "no incentives to discriminate". The "competitors" are welcome as long they bring a present. If, on the other hand, they reduce overall profits for the integrated firm they will be foreclosed. This may not be competition in a genuine sense, but more like a make-or-buy decision. In practice, firms often speak of a level playing field meaning that all firms should have equal chances. One interpretation of this concept could be that access should be non-discriminatory. The analysis above questions this. The integrated firm may have other incentives concerning the downstream market than the competitors. If the access charge is regulated sufficiently strongly, the integrated firm's downstream subsidiary faces a dilemma. It can retain its market share by suppressing the profit margin, but this reduces its own profits as well. Alternatively, it may raise the profit margin, but this would attract new entry, reducing its market share. The integrated firm should balance these short-run and long-run interests. In contrast, in the unregulated situation, there is no such dilemma; given equally efficient firms, it is unambiguously in the interest of the integrated firm to retain market share with a low profit margin. Hence, the principle of the level playing field may be violated by different incentives.

¹⁷ It should be stressed, however, that the overall situation is (allocatively) inefficient, because of the unregulated monopolistic access charge. This is in brief a point of discussion concerning the efficient component pricing rule; cf. Baumol, Ordover & Willig [1996] and Economides & White [1995].

¹⁸ This may be a real problem if the access charge is arranged in a (non-discriminatory) tariff structure rather than by individual negotiations and the competitors themselves differ in efficiency.

Nevertheless, it is noticeable that ρ decreases the more efficient the competitors are. If third parties are more efficient, the regulated access charge can be (considerably) lower than the unregulated level, before the integrated firm has an incentive to use third-party discrimination. The lower ρ reflects that the higher efficiency of the competitors is internalised via the access charge; the higher the efficiency gain, the lower the access charge can be before the downstream losses can no longer be compensated via the access charge. It turns out furthermore that ρ_2 is systematically smaller than ρ_1 . This is not surprising, because if n is small, part of the efficiency gain is offset by (partly) double marginalisation, which decreases the integrated firm's profit.

4. The electricity supply industry in Germany

As mentioned in the introduction, the recent literature on third-party discrimination relies mainly on the telecommunications sector in the USA. From a regulatory point of view, the electricity supply industry (ESI) is more clear-cut compared to telecommunications. Conceptually, the monopolistic bottlenecks (the transmission and distribution networks) are well demarcated from the complementary competitive stages (generation and retail). Moreover, the networks are genuine monopolies and by-pass via alternative technologies is close to impossible. The complementary vertical relation is strict; the downstream producers cannot substitute away from using the network. A necessary condition to allow competition in generation and retail thus is access to networks, called third party access (TPA).¹⁹ With respect to the regulation of the network-access charges and the way non-discriminatory TPA is ensured the details vary across EU-countries.²⁰ The latter range from application of general competition law to ownership separation (between monopolistic and competitive stages). The observed pattern in the EU is to have some type of sector-specific

¹⁹ In the USA it is also called wheeling.

²⁰ The interested reader may be referred to Bergman, Brunekreeft, Doyle et al. [1999] for a recent overview of the approaches in the EU and various member states.

regulation of the network-access prices and some degree of vertical separation; the EU-directive prescribes a mild form of accounting separation. The main exception is Germany, which opted for negotiated TPA. This means in practice that the network-access charges are unregulated and that issues concerning discrimination are left to the antitrust agency. To strengthen the latter's powers, an essential-facilities doctrine has been integrated into the competition act. The degree of vertical separation corresponds to the minimal requirements of the EU-directive; effectively the degree of vertical integration is high and increasing. In contrast, in the UK, the network access charges are price-cap regulated and the degree of vertical integration is low and decreasing.

What are the experiences in the German ESI so far?²¹ Surprisingly good at first sight; most remarkably, end-user prices have fallen significantly. A closer look, however, suggests a pattern predicted by theory. Results 1 and 3 of this paper appear to be confirmed by the developments in Germany. The unregulated network-access charges are high, whereas the profit margins at the generation and retail stages are very low and, consequently, there is only little new entry. Figure 1 plots the share of the network-access charge in the end-user price (cleaned for taxes) for Germany as compared to the regulated case of the UK, differentiated for various user groups.²² Figure 1 strongly suggests that the access charges in Germany are relatively high; the lack of regulation of the access charges is likely to contribute to an explanation.²³ LBD [2000] attempts to calculate a reasonable level of the access charges and indicates that the current access charges may indeed be excessively high.

²¹ The interested reader may be referred to Brunekreeft & Keller [2000] for a detailed analysis.

²² These user groups have been defined by Eurostat; D means domestic and I industrial/commercial and an higher-order second letter indicates increasing annual consumption. In Germany and the UK, the categories Dc and Dd are by far the most important.

²³ It should be noted that in contrast to e.g. the USA, the German competition law qualifies an excessive price as an abuse of a dominant position as such. So, the antitrust agency has a means against excessive pricing. This instrument seems rather weak however. Interestingly, a case against excessive pricing of TPA in the gas sector is currently being examined by the antitrust agency.

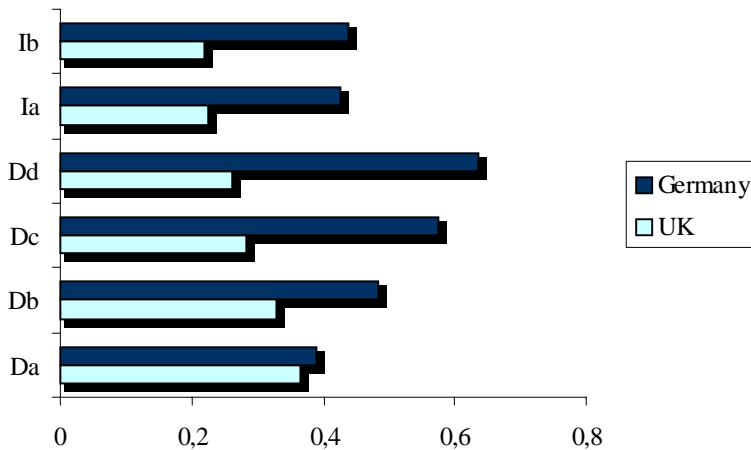


Figure 1: Share of the network-access charges in the end-user prices in 2000.
Source: Based upon Brunekreeft & Keller [2000, p. 23].

The profit margins at the generation and retail stages are very low. It is problematic to give an accurate estimate of the wholesale price of bulk power, because most of it is traded by bilateral contracts. Nevertheless there are indications that wholesale prices are roughly at short-run marginal production costs. A first indication is that several major incumbents recently announced that they would disconnect a substantial amount of generation capacity, with the argument that spot prices were in fact below marginal production costs for these types of capacity.²⁴ Second, two spot markets (EEX and LPX) which started operating in the summer of 2000 produced average spot prices somewhat lower than 4 Pf/kWh. Thus, despite a relatively highly concentrated generation market,²⁵ the spot prices are so low that they are unlikely to recover fixed costs. The profit margin in retail can be indicated by examining the end-user prices and thereby the margin which remains for a competitor. Figure 2 makes a comparison of the breakdown of the gross end-user price (both in Pf/kWh) for Germany and the Netherlands; in the latter, the ESI is regulated in a UK style. In both countries, the incumbents' average gross price is slightly higher than 29 Pf/kWh for a domestic consumer with an annual consumption of 3500 kWh. Figure 2 strongly suggests that the margin at the competitive stages in Germany

²⁴ Another explanation might be that the reduction of (excess) capacity is a signal to restrain competitive pressure. This would be a market power argument.

²⁵ The HHI in generation is approximately 2417 and the CR4 is 0.85 [cf. Brunekreeft & Keller, 2000].

is significantly lower than in the Netherlands. In the Netherlands the margin for electricity purchase and retail adds up to 9.49 Pf/kWh, while in Germany only 6.65 Pf/kWh remains; thus the Dutch margin is more than 40% higher than the German.

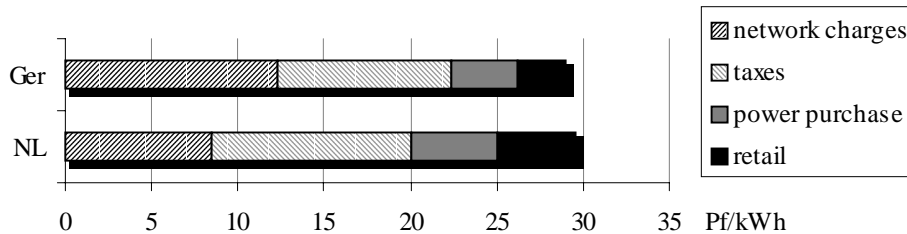


Figure 2: Breakdown of gross end-user price; for 3500 kWh annual consumption; in Pf/kWh.

Source: Own calculation.

It appears from various studies and the media that the new (retail) entrants have difficulties to settle on the market [cf. e.g. Target AG, 2000]. VDEW, which is the ESI's association, suggests that actual switching at the end of 2000 was 2% for domestic end-users and 3.5% for commercial users.²⁶ In the UK, the unweighted average market share of the incumbents in their own network area (so-called PES 1st tier) is 85% for domestic end-users and 37% in the 100kW-to-1MW market [cf. OFGEM, 2000a, p. 34 and 2000b, p. 14]. VDEW claims that the low switching level in Germany should be explained from a high customer satisfaction with the incumbent retailer and a relatively low price difference with competitors, because the incumbents lowered their prices. In the light of the analysis made above, this explanation appears plausible.

The overall picture suggests that the largely vertically integrated network owners focus on the level of the (unregulated) access charges. Simultaneously, they do not appear to be overly interested in a high profit margin at the competitive stages. On the contrary, they should have and appear to have an interest in trying to limit a mark up at these stages. It follows that the independent competitors have a hard time competing with incumbents. Thus one might actually expect a situation as derived in result 3; the market shares of the

²⁶ From a personal correspondence with VDEW. The market survey agency, GfK (<http://www.gfk.de>) has a slightly more optimistic estimate.

network operators in their host areas are overwhelming, whereas the profit margins of the competitive stages are very low. The independents claim that the behaviour of the network operators is discriminatory. There is no denying that there is some discrimination, but it does not appear to be systematic.²⁷ A critical point for competition policy is that if the antitrust agency concentrates on pursuing genuine discriminatory behaviour it will achieve close to nothing, because the profit margin at the competitive stages will remain small. If the authorities wish to promote actual competition, they will have to set incentives for a larger profit margin at the competitive stages by regulating the network-access charges. In that case the network operators will have an incentive to try to make some profit on the complementary stages, which will open up new possibilities for the entrants. Simultaneously, however, the incentives for third-party discrimination would increase substantially.²⁸

5. *Concluding remarks*

This paper has explored the relation between the access charge, the efficiency difference, downstream competitiveness and the incentives for third-party discrimination in detail. The insights are illustrated by means of the developments in the electricity supply industry in Germany. The formal setting in the paper exploits the trade off between the effect of double marginalisation (due to imperfect downstream competition) and the effect of more efficient competitors. The integrated firm will welcome the more efficient competitors if it can compensate foregone downstream profits with additional upstream profits through a higher access charge. The more efficient the competitors are, the higher the upstream profits can be. The effect of imperfect competition partly offsets this possibility.

²⁷ It may be noted that there are approximately 800 network operators with strongly varying characteristics. Since the incentives depend at least partly on parameters, it seems implausible that all network operators do in fact have the same incentives.

²⁸ Riechmann [2000] shows a positive correlation between a lower access charge and a lower competitors' market share in the electricity retail market in the UK. This suggests that the possibilities for third-party discrimination are strong. It may not be surprising that the UK is now introducing a very strict form of management separation of the distribution versus retail businesses.

If the prices of the upstream stage (i.e. access charges) are not regulated, the integrated firm will not have an incentive to discriminate against third parties, unless it has an explicit reason to do so. This demarcates the reference case, as has been emphasised by the Chicago school of antitrust analysis. On the other hand, if the access charges are regulated sufficiently strongly, the incentives for third-party discrimination do arise; due to the regulation, the integrated firm will not be able to compensate foregone downstream profits by higher upstream profits. Consequently, the firm will attempt to lever its upstream market power to the downstream stage by foreclosing it. There is a level of the access charges at which the integrated firm is indifferent with respect to discrimination of third parties. This switching level depends on the (potential) competitiveness of the downstream market and the relative efficiency of the downstream competitors as compared to the integrated firm's downstream subsidiary.

One point is of particular interest. If the integrated firm's downstream subsidiary and the downstream competitors are equally efficient, the level of the access charge at which the integrated firm is indifferent with respect to third-party discrimination is exactly the unregulated level. The latter is exactly so high that no entry takes place at the margin. This implies -given equally efficient downstream competitors- that entry will not take place, although the behaviour of the integrated firm is not discriminatory. The profit margin at the downstream stage is simply too small to make it attractive to enter.

Despite the fact that in the reference case behaviour may be non-discriminatory, one may question the competitive potential following from it. In the unregulated situation, the integrated firm has an unambiguous interest to retain market share with a low downstream profit margin. In contrast, if the access charge is regulated sufficiently strongly, the integrated firm's downstream subsidiary faces the normal strategic dilemma. It can retain market share by suppressing the profit margin, but this reduces its own profit as well. Or it may raise the profit margin, but this would attract new entry, reducing its market share. The integrated firm should balance these short-run and long-run interests. Thus in the unregulated situation, the incentives of the integrated firm are different from those of its downstream "competitors".

All this has severe implications for regulation and/or competition policy. If entry on the competitive stage is insignificant in a situation where the access charges are unregulated, a policy of strict prohibition of discriminatory behaviour is not likely to achieve much. The problem is the low downstream profit margin due to the high access charge. The appropriate approach thus is to regulate the access charges. This would give the competitors equal chances, starting with equal incentives. Obviously, however, the incentives to discriminate against third parties would increase substantially.

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Appendix 1: Proof of result 1

It is to be shown that the profit for $z = 0$ is larger than for $z = z^F$, for the unregulated case. Recall that $Q_E^* = 0$ and $\lambda_2 \geq 0$, $Q_I^* = Q^*$ and thus $\lambda_3 = 0$. Moreover, $\lambda_1 = 0$; given the discontinuous solution of $z > 0$, the integrated firm cannot increase its profits beyond complete foreclosure. Thus, given that z is such that the downstream market is completely foreclosed, a slight increase in the (allowed) access charge would not increase profit and, consequently, the shadow price of the access charge is zero. The integrated firm could increase its profit by switching to the $z = 0$ -solution. This is a discontinuous switch, however. For $Q_E^* = 0$, $\lambda_1 = \lambda_3 = 0$, it follows from (20) and (21):

$$Q^F = Q_I^F = \frac{a - MC_I^D - MC^U}{2b}, \text{ and } P^F = \frac{a + MC_I^D + MC^U}{2}. \quad (34)$$

It should be shown that $\pi_I^{NR,S} > \pi_I^F$. On the left hand side, the $n = 1$ -case should be taken, because for the unregulated case profits increase with the number of competitors n . Thus if the statement is true for $n = 1$, it is also true for $n > 1$. It should be compared whether:

$$(P^S - MC_I^D - MC^U)Q_I^S + (r - MC^U)Q_E^S > (P^F - MC_I^D - MC^U)Q^F. \quad (35)$$

The second term on the left-hand side can be rewritten as:

$$\left(P^S - MC_I^D - MC^U + \frac{MC_I^D - MC_E^D}{2} \right) Q_E^S. \quad (36)$$

Noting that P^F is equivalent to P^S and thus Q^F is equivalent to Q^S , it follows that:

$$\left(\frac{MC_I^D - MC_E^D}{2} \right) Q_E^S > 0, \text{ for } MC_I^D > MC_E^D. \quad (37)$$

And thus $\pi_I^{NR,S} > \pi_I^F$. Note the equality if the firms are equally efficient.

Appendix 2: Proof of result 2

It is to be shown that $\pi_I^{R,S} < \pi_I^F$. Note that $\pi_I^{R,S} = (P^{R,S} - MC_I^D)Q_I^{R,S}$, because $\bar{r} = MC^U$. If $\lambda_3 > 0$ ($Q_I = 0$) with $\bar{r} = MC^U$, obviously the profits of the integrated firm are zero. Consequently, it would be profitable to use z to foreclose the market. If, on the other hand, $\lambda_2 > 0$ (and $\lambda_3 = 0$), because $MC_E^D \gg MC_I^D$, the best that can happen is the outcome which results with complete foreclosure; i.e. z is so high that the foreclosure monopoly outcome results. Consequently, the profit $\pi_I^{R,S}$ cannot be higher than π_I^F . It follows that for the case $\lambda_2 = \lambda_3 = 0$, $\pi_I^{R,S} < \pi_I^F$.

It should further be shown that $\pi_I^{R,B} < \pi_I^F$, for the case $n > \tilde{n}$. Note that:

$$Q_E^{R,B} = \frac{n}{b} \left(\frac{a - 2\bar{r} + (n+1)MC_I^D - (n+2)MC_E^D + MC^U + n\lambda_2 - (n+1)\lambda_3}{2(n+1)} \right) \quad (38)$$

If the term between round brackets is denoted by $x(n)$, then the limit of $x(n)$ for $n \rightarrow \infty$ is:

$$\lim_{n \rightarrow \infty} x(n) = \frac{1}{2} (MC_I^D - MC_E^D + \lambda_2 - \lambda_3)$$

It then follows that $\lim_{n \rightarrow \infty} Q_E^{R,B}$ can only be a real number (different from zero) if $MC_I^D = MC_E^D$ and $\lambda_2 = \lambda_3 = 0$. If $MC_I^D < MC_E^D$, $\lambda_2 > 0$ and thus $Q_E^* = 0$, while if $MC_I^D > MC_E^D$, $\lambda_3 > 0$ and thus $Q_I^* = 0$. This means that with perfect price competition on the downstream market, only the most efficient firm(s) will remain on the market. Substituting $MC_I^D = MC_E^D = MC^D$, $\lambda_2 = \lambda_3 = 0$, $\bar{r} = MC^U$ and $z = 0$ then gives:

$$\lim_{n \rightarrow \infty} P^{R,B} = MC^U + MC^D, \quad (39)$$

which corresponds to the competitive outcome under social-welfare maximising regulation of the access charge, given a large number of competitors. The profit of the integrated firm is zero in this case and thus there are strong incentives for third-party discrimination. Overall, for $\bar{r} = MC^U$ it follows that $\pi_I^R < \pi_I^F$.

Appendix 3: Derivation of the switching point

This appendix derives the values of first ρ_1 and second ρ_2 . Define ρ_1 as:

$$\rho_1 = \frac{a - MC_E^D + MC^U}{2} - \alpha_1. \quad (40)$$

and find α_1 for which $\pi_I^F = \pi_I^{\rho_1}$:

$$(P^F - MC_I^D - MC^U)Q^F = (P - MC_I^D - MC^U)Q_I + (\rho_1 - MC^U)Q_E. \quad (41)$$

Rewrite the right-hand side as far as possible in term of P^F and Q^F and simplify. In particular:

$$P = P^F - \frac{n}{n+1}\alpha_1 \text{ and thus } Q = Q_I + Q_E = Q^F + \frac{n}{n+1}\frac{1}{b}\alpha_1 \quad (42)$$

$$\text{and } \rho_1 - MC^U = P^F - MC_I^D - MC^U + \frac{MC_I^D - MC_E^D}{2} - \alpha_1. \quad (43)$$

Eq. (41) then reduces to:

$$-\left(\frac{n}{n+1}\right)^2 \frac{1}{b}\alpha_1^2 - \frac{1}{n+1}\alpha_1 Q_E + \left(\frac{MC_I^D - MC_E^D}{2}\right)Q_E = 0. \quad (44)$$

From (14), using (40) and the fact that $Q_I = Q - Q_E$, it follows that:

$$Q_E = -n\left(\frac{MC_E^D - MC_I^D}{2}\right) + \left(\frac{n}{n+1}\right)\frac{1}{b}\alpha_1, \quad (45)$$

which after substituting in (44) results in:

$$\alpha_1 = \frac{\sqrt{(n+1)}(MC_I^D - MC_E^D)}{2}, \quad (46)$$

and thus eq. (32) results:

$$\rho_1 = \frac{a - MC_E^D + MC^U}{2} - \frac{\sqrt{(n+1)}(MC_I^D - MC_E^D)}{2}. \quad (47)$$

A similar procedure gives ρ_2 , for $n > \tilde{n}$; this will be given for $n \rightarrow \infty$. First, define ρ_2 :

$$\rho_2 = \frac{a - MC_I^D + MC^U}{2} - \alpha_2. \quad (48)$$

Note that this way of defining ρ_2 is slightly different from ρ_1 as in (40), because it turns out to be more convenient. As before, find α_2 such that $\pi_I^F = \pi_I^{\rho_2}$. Recall that for this case, $\lambda_3 > 0$, which means that $Q_I = 0$, and $Q_E = Q$:

$$(P^F - MC_I^D - MC^U)Q^F = (\rho_2 - MC^U)Q. \quad (49)$$

Substituting (48), rewriting and simplifying then gives:

$$-\left(\frac{a - MC_I^D - MC^U}{2b}\right)(MC_E^D - MC_I^D - \alpha_2) - \alpha_2 Q = 0. \quad (50)$$

Noting that the first term between round brackets is Q^F and noting that:

$$Q = Q^F - \frac{1}{b}(MC_E^D - MC_I^D - \alpha_2), \quad (51)$$

substituting, writing out and solving for α_2 then results in:

$$\alpha_{2,(1,2)} = \frac{(MC_E^D - MC_I^D) \pm \sqrt{(MC_E^D - MC_I^D)^2 - 4bQ^F(MC_E^D - MC_I^D)}}{2}. \quad (52)$$

Examination of (52) quickly reveals that "+" is the appropriate sign in front of the root; otherwise α_2 could be negative for $MC_E^D < MC_I^D$, which is counterintuitive and incorrect. Thus, after substituting in (48) and rewriting slightly, eq. (33) results:

$$\rho_2 = \frac{a - MC_E^D + MC^U}{2} - \frac{\sqrt{(MC_E^D - MC_I^D)^2 - 4bQ^F(MC_E^D - MC_I^D)}}{2}. \quad (53)$$

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